

Volume Table of Raintree (*Samanea saman*) in Bangladesh by Regression Technique

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ABSTRACT

Raintree (*Samanea saman*) is a multipurpose village tree species grown in abundance at southern and northern regions of Bangladesh. Village people need to know estimation procedure for timber inventory of this useful tree species. Data on diameter at breast height (diameter) and total height (height) of 205 standing sample trees were collected by Spiegel relascope for the purpose. The sample trees with diameter ranging 21 cm - 91 cm and height ranging 10 m - 20 m were considered for measurement. Volumes (m^3) of individual trees were computed by Smalian formula. A total of 10 linear models of volume on diameter and volume (V) on diameter (D) and height (H) were examined with the sample trees. A few statistics of F, t, mean square error, multiple correlation coefficient and Furnivall Index was computed and tested for investigation of best fitted models. The two models of $\ln(V) = 8.3023 + 2.1746 \ln(D)$ and $\ln(V) = -9.1864 + 1.85502 \ln(D) + 0.8234 \ln(H)$ were found to be best fitted models. They have been recommended to estimate volume of large scale standing Raintree trees.

Keywords: Volume Table; Raintree; Regression Technique; Profitable

1. Introduction

Raintree (*Samanea saman*) is a large tree mostly grown in southern and northern parts of Bangladesh. It is one of the most important species in Barisal and Khulna districts where it contributes some 19% of the total volume [1]. It is also planted at higher rate in Patuakhali and Rajshahi. It occupies as best region in respect of number of trees in Chittagong. It is also planted along roadside in many areas in the country. It is an exotic and multipurpose tree species. Village people use its stem and branches as timber and fuel wood respectively. It is also a good fodder tree. Village people get financial benefit out of its plantation.

The local volume tables for important village tree species such as am, jackfruit, jam, mandar, etc were prepared separately by regression technique during Village Forest Inventory in 1981 [2]. The volume tables for teak (*Tectona grandis*), gamar (*Gmelina arborea*), and jarul (*Lagerstroemia speciosa*) were prepared by regression techniques. These species are grown in plantation. Volume table of total 30 indigenous forest species grown naturally were prepared [3]. It is obvious that volume tables for all commercial tree species are available except volume table for Raintree. But volume table of Raintree species is essential for timber inventory works of Forest Department as well as for prospective growers.

In view of above discussions the present study is un-

dertaken to establish best relation of volume vs. diameter (one-way volume table) and volume vs diameter and height (two-way volume table) for Raintree planted in both village areas and forest land by multiple regression analysis.

2. Materials and Method

A data collection sheet was developed for recording data of Raintree. Since it was not technically feasible to cut standing Raintree trees in the villages, it was decided to measure the standing trees. A team of two persons were engaged for recording measurement of the sample standing trees. One person measured the trees and another person recorded data in the sheet. The total height of a tree in the sample was first measured by Spiegel relascope instrument and was recorded in the sheet [4]. Diameter at breast height of the tree was measured in cm by a diameter tape. Diameters at every 10 ft height and at height of the top log with 8 inch diameter were measured by the same relascope instrument. Diameter at two ends of branch logs was also measured by relascope. Branches with minimum 8" top diameter were recorded in remarks column of the sheet. The sample trees having 23% branchy trees were considered. The species was identified easily in the field. In this way data of a sample of 205 trees were recorded in the sheets. Measurement error due to instrumental error as well handling error was re-

duced by fixing up the instrument properly through actual measurement of a few trees by climbing or felling [5]. A stand table (**Table 1**) showing an average of 25 trees per diameter class and an average of 35 trees per height class.

All measurement data collected in feet were converted into metric unit through computer. Volume of each log section was calculated by Smalian formula ($V = L/2 (S' + S'')$, V = Volume overbark, S' = area of base, S'' = area of top and L = Length of log section.) [6]. Volume of each sample tree up to 20 cm diameter and volume up to the tip height (using conical formula) were calculated through computer. Thus three variables namely, diameter (cm), height (m) and volume (m^3) of a tree were generated. The volume regressions were fitted for the sample trees. The following regression equations [7] were considered for selection of best fitted models:

- 1) $V = a + bD$
- 2) $V = a + bD^2$
- 3) $\ln(V) = a + b \ln(D)$
- 4) $V = a + bD + cD^2$
- 5) $V = a + bD^2H$
- 6) $\ln(V) = a + b \ln(D) + c \ln(H)$
- 7) $V = a + bD^2 + cH + dD^2H$
- 8) $V = a + bD^2 + CDH + dD^2H$
- 9) $V/D^2H = a + bD^2H + C/H + d/D^2$
- 10) $V/D^2H = a + bD^2H + C/H + d/D$

where, V = Volume (m^3) overbark, D = diameter (cm) at

breast height, H = total height (m), a = regression constant and b, c, d = regression coefficients.

The regression equation through the selection tests such as F-test, t-test, coefficient of determination (R^2), mean square error (MSE) and Furnivall Index (FI) were examined. Furnivall Index is estimated through multiplying square root of the residual mean square of a volume regression by geometric mean of the weight of the dependent variable [8]. It was first developed by Furnivall in 1961 for weighted models [9]. The best regression equations were selected and particularly, the best models of volume-diameter (One-Way Volume Table) and volume-diameter-height (Two way volume table) may be used to compute volume of standing raintree trees as per requirement.

3. Result and Discussion

A total of 10 regression equations mentioned earlier was fitted with 205 sample trees [10]. A few statistics such as F, t, MSE, R^2 and FI were computed and compared for each of 10 regression equations. On the basis of F & t significance, small MSE & FI and more R^2 the two models were selected and shown in **Table 2**.

The amount of variation explained by the two models is 86% and 90% respectively. The variation explained is quite a good amount, FI which contains MSE indicates small figure for both the models, F and t show highly significant. So, the two models have been selected as suitable ones. The volume-diameter model is, however, only considered for the purpose of calculating volume of a Raintree tree [11]. This is the model by which volume

Table 1. Stand table of 205 sample trees.

Diameter (cm)	Height (m)						Total
	10	12	14	16	18	20	
21	23	8	8	-	-	-	29
31	24	28	15	1	-	-	68
41	10	22	12	5	-	-	49
51	7	14	10	7	2	1	41
61	2	4	-	5	1	1	13
71	-	-	1	1	1	-	3
81	-	-	-	1	-	-	1
91	-	-	-	-	-	1	1
Total	56	76	46	20	4	3	205

Table 2. The statistics of best selected models.

Model	MSE	FI	R^2	F	t_1	t_2
1 $\ln(V) = -8.3013 + 2.1746 \ln(D)$	0.07	0.21	0.86	1273.79	35.69	-
2 $\ln(V) = -9.1864 + 1.8502 \ln(D) + 0.8234 \ln(H)$	0.05	0.18	0.90	916.98	29.09	8.24

of a large number of standing Raintree trees can be estimated quickly through measurement of diameter at breast height only. The volume table prepared on the basis of this volume-diameter model is called one way volume table and shown in Appendix I. Another model needs measurement of both diameter at breast height and total height of standing trees [12]. Although it takes time and sometimes difficult to measure the total height of the standing trees correctly, this model provides better volume estimates than another model. The volume table prepared on the basis of this volume-diameter-height model is called two way volume tables and shown in Appendix II. Actual volume of same sample felled trees measured for verification during data collection was calculated. This calculated volume was compared with the estimated volume taken from both one-way volume table and two-way volume table. It is found that the estimated volume is almost same as the actual volume of Raintree trees. Therefore, the two volume tables may be used to compute volume of standing Raintree trees.

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Appendix I. One Way Volume Table (m³)

Regression Equation: $\ln(V) = -8.3013 + 2.1746\ln(D)$.

Species: Raintree (*Samania saman*)

Total volume over bark = Stem volume over bark up to 10 cm top diameter + Branch wood volume over bark up to 10 cm top diameter.

Diameter (cm)	Volume (m ³)
20	0.1675
22	0.2061
24	0.2490
26	0.2963
28	0.3482
30	0.4045
32	0.4655
34	0.5311
36	0.6013
38	0.6764
40	0.7562
42	0.8408
44	0.9303
46	1.0248
48	1.1241
50	1.2285
52	1.3379
54	1.4523
56	1.5718
58	1.6965
60	1.8262
62	1.9612
64	2.1014
66	2.2468
68	2.3975
70	2.5535
72	2.7149
74	2.8815
76	3.0536
78	3.2310
80	3.4139
82	3.6022
84	3.7960
86	3.9953
88	4.2001
90	4.4105
92	4.6264
94	4.8479
96	5.0750
98	5.3078
100	5.5461

Appendix II. Two Way Volume Table (m³)Regression Equation: $\ln(V) = -9.1864 + 1.8502\ln(D) + 0.8234\ln(H)$ Species: Raintree (*Samania saman*)

Total volume over bark = Stem volume over bark up to 10 cm top diameter + Branch wood volume over bark up to 10 cm top diameter.

		Height (m)					
		10	12	14	16	18	20
Diameter (cm)	20	0.1742	0.2024	0.2298	0.2565	0.2826	0.3082
	22	0.2078	0.2414	0.2741	0.3059	0.3371	0.3676
	24	0.2440	0.2836	0.3219	0.3594	0.3960	0.4318
	26	0.2830	0.3288	0.3733	0.4167	0.4592	0.5008
	28	0.3246	0.3772	0.4282	0.4780	0.5266	0.5744
	30	0.3688	0.4285	0.4865	0.5430	0.5984	0.6526
	32	0.4156	0.4829	0.5482	0.6119	0.6742	0.7353
	34	0.4649	0.5402	0.6133	0.6846	0.7543	0.8226
	36	0.5167	0.6004	0.6817	0.7609	0.8384	0.9144
	38	0.5711	0.6636	0.7534	0.8410	0.9266	1.0106
	40	0.6280	0.7297	0.8284	0.9247	1.0189	1.1112
	42	0.6873	0.7986	0.9067	1.0121	1.1151	1.2162
	44	0.7491	0.8704	0.9882	1.1030	1.2154	1.3255
	46	0.8133	0.9450	1.0729	1.1976	1.3195	1.4391
	48	0.8799	1.0224	1.1608	1.2957	1.4276	1.5570
	50	0.9489	1.1026	1.2519	1.3973	1.5397	1.6792
	52	1.0203	1.1856	1.3461	1.5025	1.6555	1.8056
	54	1.0941	1.2714	1.4434	1.6112	1.7753	1.9362
	56	1.1703	1.3599	1.5439	1.7233	1.8988	2.0709
	58	1.2488	1.4511	1.6475	1.8389	2.0262	2.2098
	60	1.3296	1.5450	1.7541	1.9580	2.1574	2.3529
	62	1.4128	1.6416	1.8638	2.0804	2.2923	2.5000
	64	1.4983	1.7410	1.9766	2.2063	2.4310	2.6513
	66	1.5861	1.8430	2.0924	2.3356	2.5734	2.8066
	68	1.6761	1.9476	2.2112	2.4682	2.7195	2.9660
	70	1.7685	2.0549	2.3330	2.6042	2.8694	3.1294
	72	1.8631	2.1649	2.4579	2.7435	3.0229	3.2969
	74	1.9600	2.2774	2.5857	2.8862	3.1801	3.4683
	76	2.0591	2.3926	2.7164	3.0322	3.3409	3.6437
	78	2.1605	2.5104	2.8502	3.1814	3.5054	3.8231
	80	2.2641	2.6308	2.9869	3.3340	3.6735	4.0065
	82	2.3699	2.7538	3.1265	3.4899	3.8453	4.1938
	84	2.4780	2.8794	3.2690	3.6490	4.0206	4.3850
	86	2.5882	3.0075	3.4145	3.8113	4.1995	4.5801
	88	2.7007	3.1382	3.5629	3.9770	4.3820	4.7791
	90	2.8154	3.2714	3.7141	4.1458	4.5680	4.9820
	92	2.9322	3.4072	3.8683	4.3179	4.7576	5.1888
	94	3.0513	3.5455	4.0253	4.4931	4.9507	5.3994
	96	3.1725	3.6863	4.1852	4.6716	5.1474	5.6139
	98	3.2958	3.8297	4.3480	4.8533	5.3476	5.8322
	100	3.4213	3.9755	4.5136	5.0381	5.5512	6.0543